Estimating Secondary Impacts from Single Sources

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• All information presented is considered preliminary by the U.S. Environmental Protection Agency and is provided to describe and illustrate potential modeling approaches and complex ideas.
• This work is evolving and some or all of the information presented in this presentation may change.
Motivation

• **New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs**
  – Assess the air quality impacts of new or modified sources related to precursor emissions for Ozone and PM2.5
  – EPA granted Sierra Club petition with commitment to update Appendix W to address O3 and secondary PM2.5 impacts
  – Interpollutant trading (NSR offset) provisions for PM2.5

• **National Environmental Policy Act (NEPA)**
  – Assess the environmental impacts of new or modified sources
What models?

- Air quality models exist to assess urban-scale impacts of primarily emitted pollutants from single sources for permit related purposes (AERMOD)
- What models are appropriate for estimating the impacts of secondarily formed pollutants (PM2.5 and ozone) from single sources on urban and regional scales?
- A variety of modeling systems exist that either treat single and/or multi-source systems
  - Photochemical box models
    - OZIPR
  - Lagrangian models
    - CALPUFF
    - SCIPUFF/SCICHEM
    - HYSPLIT & FLEXPART
  - Photochemical transport models
    - CMAQ and CAMx
- How are these different approaches comparable and how best to apply models for single source and cumulative impact analyses?
- Models/techniques must be able to be applied for entire year(s) for PM and ozone season(s) for ozone, reflect source and geographic characteristics, and credibly account for atmospheric chemistry
National Association of Clean Air Agencies (NACAA) recommendation of a multi-tier approach to assessing urban-scale single source impacts of PM2.5 (did not address ozone) that ranges from simple (screening level) to complex:

1) Use AERMOD for primary PM2.5 with offset ratios to approximate secondary PM2.5; location specific offset ratios difficult to estimate

2) Use a Lagrangian model with plume chemistry (e.g. CALPUFF, SCICHEM)

3) Use a photochemical modeling system (e.g. CAMx, CMAQ)

PM2.5 permit guidance currently focuses on areas #1 and #3
Technical Challenges

• How far away from a source are the highest impacts of primary and secondary PM2.5 and ozone? Does this change based on stack characteristics or other factors?
• How well are near-field and long-range pollutant transport characterized by Lagrangian and Eulerian modeling systems?
• How well do Eulerian and Lagrangian modeling systems characterize plume chemistry?
• How well do Eulerian and Lagrangian modeling systems characterize the chemical and physical environment around the plume?
• How best to develop screening tools?
Long Range Transport

- PSD/NEPA
- Inert tracer experiments: GP80, ANATEX, CAPTEX
- HYSPLIT, FLEXPART, CAMx inert mode

“Documentation of the Evaluation of CALPUFF and Other Long Range Transport Models Using Tracer Field Experiment Data”
http://www.epa.gov/scram001/reports/EPA-454_R-12-003.pdf
Long Range Transport: Secondary Impacts

• Comparing sum of all tracked point and area sources in the Four Corners 4 km domain against available observation data
  – AQS data for SO2 and NOX
  – CASTNET for SO2, PM2.5 SO4, HNO3, PM2.5 NO3
  – IMPROVE for PM2.5 SO4 and PM2.5 NO3

• Also examined concentration and deposition estimates for reasonableness

• IMPROVE, CASTNET & NADP
Precursor gas SO2 (via emissions)

Conversion to PM2.5 sulfate

CALPUFF

SO2 DRY

SO2 WET

SO4 DRY

SO4 WET

CAMx

SO2 DRY

SO2 WET

SO4 DRY

SO4 WET

Precursor gas SO2 (via emissions)

Conversion to PM2.5 sulfate
Precursor gas: SO2

PM2.5 Sulfate Ion

Sulfate Wet Deposition

Precursor gas: HNO3

PM2.5 Nitrate Ion

Nitrate Wet Deposition
Using a Lagrangian Model: SCICHEM beta

- Conduct “Beta” testing of SCICHEM-2012
  - Compare SCICHEM-2012 and CMAQ estimates
  - Evaluate SCICHEM-2012 predictions against in-plume observations
- 12 traverses of plume downwind of the TVA power plant on 6 July 1999 at an average altitude of 500 m
  - Clear day with light winds from west/northwest
- Observed species include O_3, NO, NO_2, NO_x, and SO_2
Using a Chemical Transport Model (CTM)

• Need to isolate the contribution/impacts of single sources
  – Brute force emissions adjustment
  – HDDM (higher-order direct decoupled method)
  – Source apportionment
• May need techniques or an approach for situations when sources and key receptors are in very close proximity (within the same grid cell or in neighboring grid cells)
  – Sub-grid plume treatment (CAMx PiG, CMAQ APT)
  – Nesting to finer grids
• Given these models have not been applied often for single source applications in the past, application and evaluation are needed to develop an appropriate approach for permit assessments
  – EPA’s modeling guidance for attainment demonstrations is not applicable for permit impact assessments
Isolating Single Source Impacts in a CTM

- Photochemical models used: CMAQ v5.0 and CAMx v5.40
- Domains (34 layers): 36 km CONUS → 12 → 4 km
- 4 km domain NX=36, NY=36 grid cells
- 1999 hour specific CEM emissions for TVA Cumberland
- 1999 hour specific biogenics estimated with BEIS model
- 2001 NEI based anthropogenic emissions
- Meteorological inputs generated using the WRF model version 3.3
2 week (July 1999) episode maximum impact on NOX (NO+NO2) from source NOX

*red dot indicates source location
2 week (July 1999) episode maximum impact on ozone from source NOX
2 week (July 1999) episode maximum impact on **elemental carbon** from source EC

Current version of CAMx (5.40) only includes DDM for gases

*red dot indicates source location*
2 week (July 1999) episode maximum impact on **PM2.5 sulfate** from source SOX

Current version of CAMx (5.40) only includes DDM for gases

*red dot indicates source location*
Source/Receptor Proximity Issues in CTM

- Sub-grid plume treatment and sub-grid sampling provide information about source concentration at receptors within the same cell as the source.

- Plot shows PiG puffs using 2 different approaches to estimating wind shear impacts on the plume.

- The PiG plume continues to be far wider than aircraft measurements suggest.

Plot courtesy of ENVIRON. Taken from *Evaluation of Chemical Dispersion Models using Atmospheric Plume Measurements from Field Experiments*, EPA Contract No: EP-D-07-102, WA No: 4-06 and 5-08.
Source/Receptor Proximity Issues in CTM

- 200 m high-resolution grid sensitivity shown with color contours.
- While the standard PiG run tracks the centerline well, it is about six times wider than the high resolution plume.
- What is an appropriate configuration of sub-grid plume treatment for multi-year regulatory modeling applications?

Plot courtesy of ENVIRON. Taken from Evaluation of Chemical Dispersion Models using Atmospheric Plume Measurements from Field Experiments, EPA Contract No: EP-D-07-102, WA No: 4-06 and 5-08
Are screening level tools for single source estimates of secondary PM2.5 and ozone feasible?

• A screening tool would ideally provide a quick, reasonable, credible, and appropriately conservative assessment of single source secondary impacts before more complex modeling may be required.

• ENVIRON presented a reduced form single source screening model that estimates ozone impacts from single source emissions of VOC and/or NOX based on CAMx-HDDM.  

• OAQPS plans to explore this approach for ozone and PM2.5 to support single source impact assessments for multiple case study areas.

• This modeling may also provide some information for developing updated interpollutant trading ratios for PM2.5.
Future Directions

• Evaluate single source models/techniques on a 1) theoretical fit for purpose basis and 2) operationally against field studies (or other innovate approaches)

• Compromises may be necessary between approaches used to capture field measurements and multi-year regulatory modeling requirements

• Focus on identifying credible “screening level” approach(s) for single source secondary impacts on ozone and PM2.5 as EPA does not expect photochemical model application to be done in all cases

• Ultimately, as necessary, EPA will provide more guidance on an appropriate approach for model application for secondary impact permit assessments

• Need to continue to evaluate fine scale modeling (<= ~4 km) and sub-grid plume treatment approaches